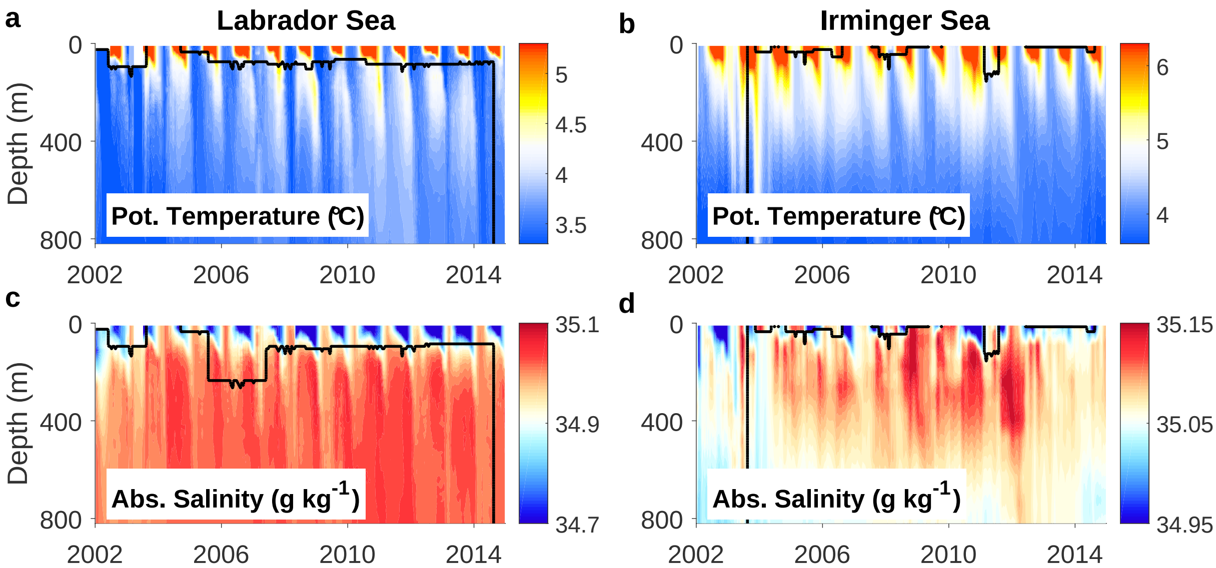
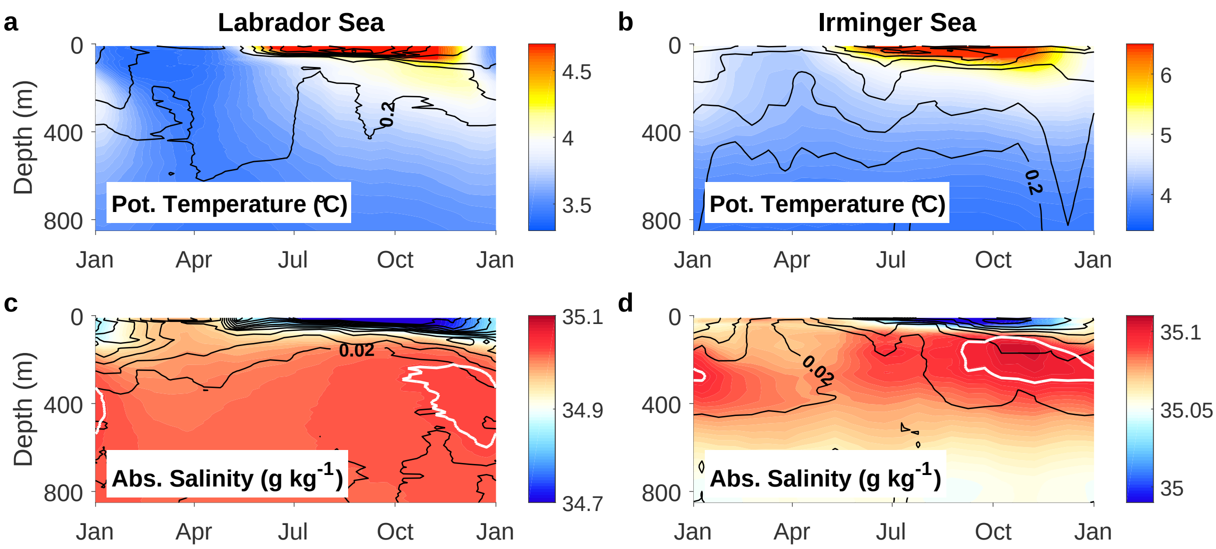
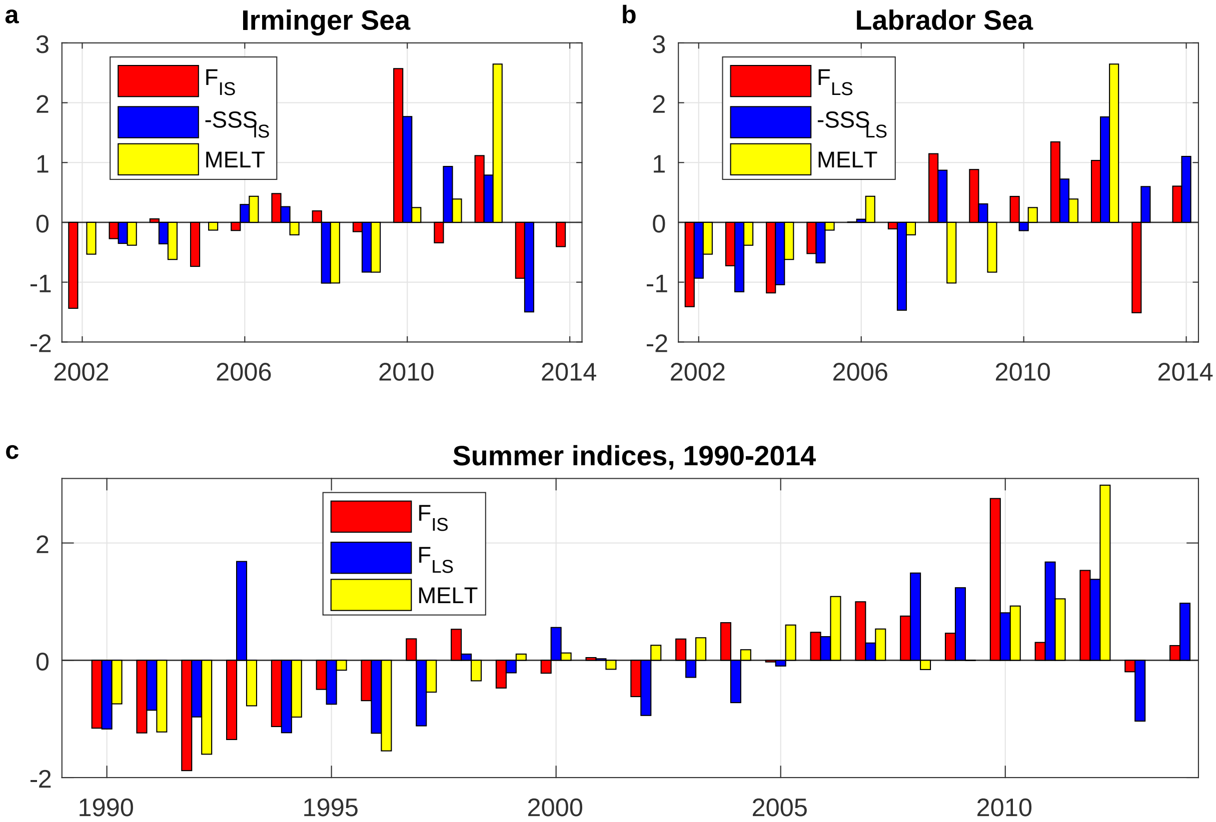


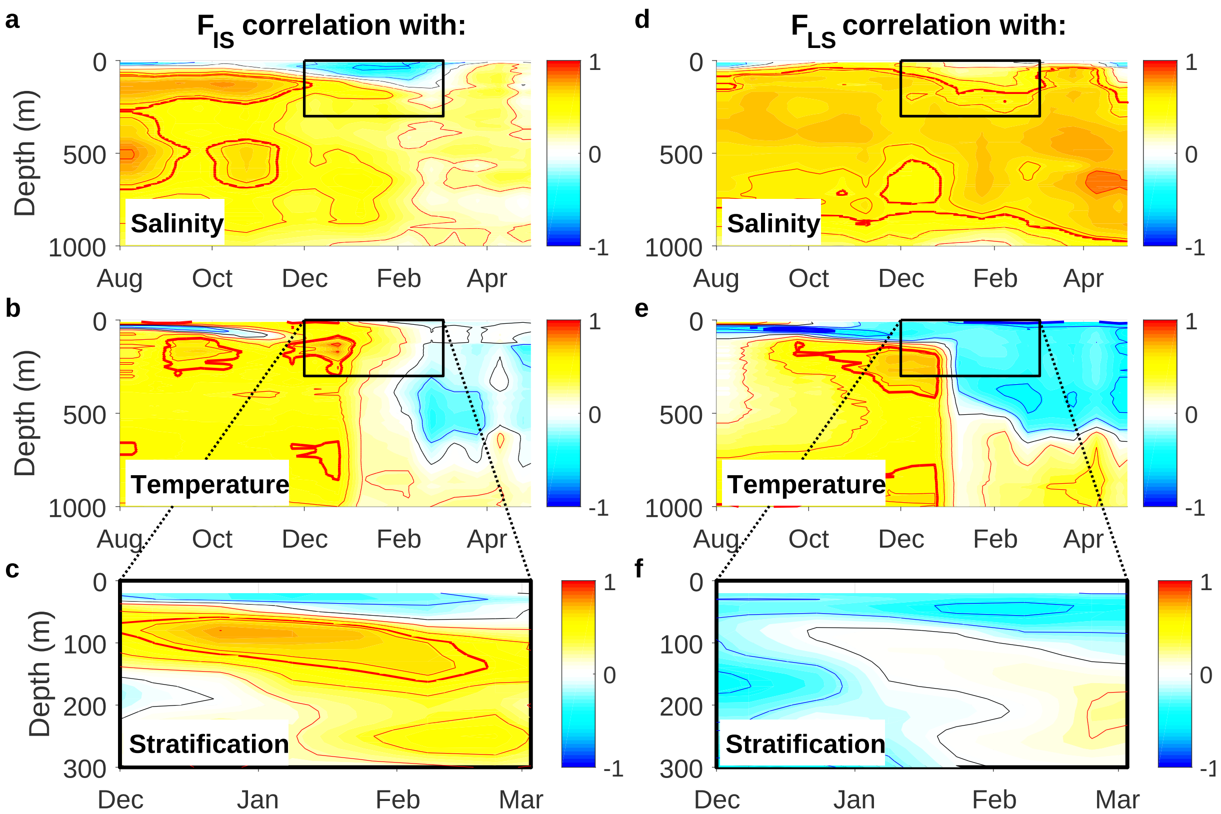
Supplementary Figure 1 | Hydrographic variability in the subpolar gyre. Potential temperature and absolute salinity in the Labrador and Irminger Seas from 2002 through 2014, derived from mooring and Argo float observations (see Method for details). Black contours delineate the periods covered by mooring data.



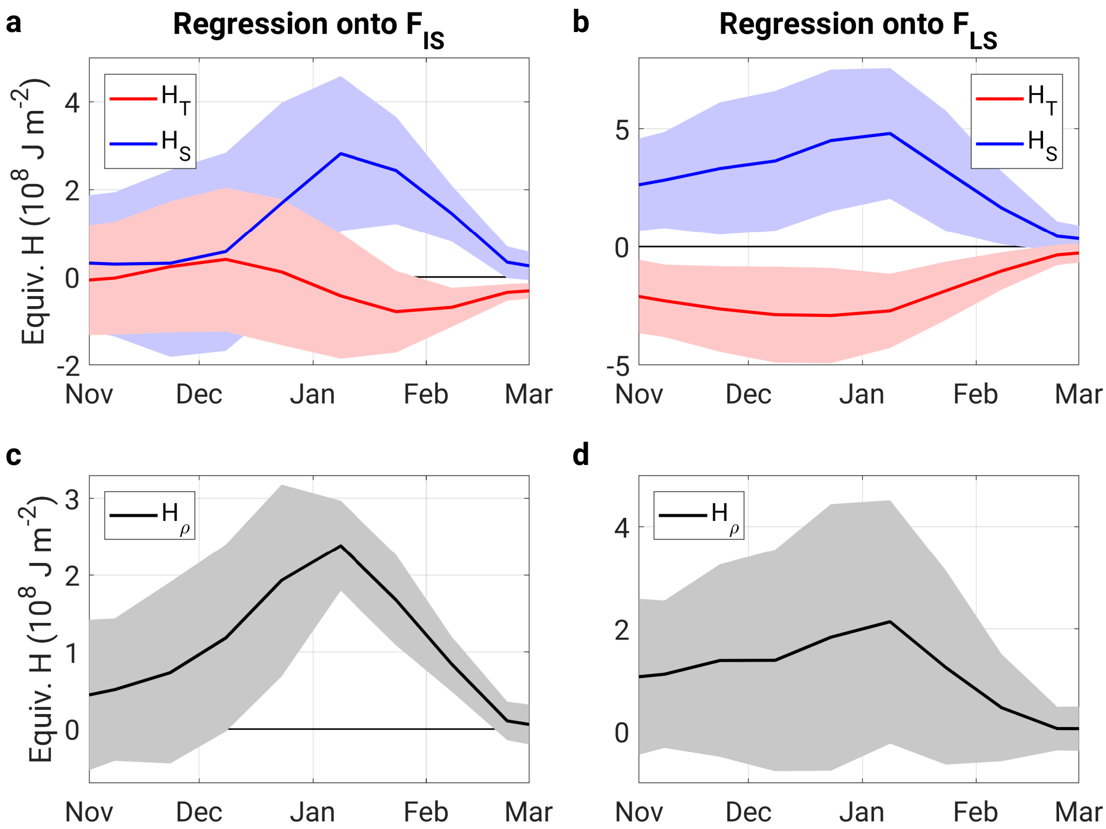
Supplementary Figure 2 | Mean annual cycle of the subpolar gyre hydrography. Mean annual cycle of potential temperature and absolute salinity in the Labrador and Irminger Seas, based on the hydrographic records shown in Supplementary Fig. 1. Black contours represent the interannual standard deviation at intervals of 0.1 °C and 0.01 g kg^{-1} and white contours indicate the subsurface salinity maxima.



Supplementary Figure 3 | Summer indices. a, F_{IS} with the mean Greenland melt extent from July through August, derived from satellite data[1] and the negative SSS anomalies in the Irminger Sea, averaged over the upper 30 m at the beginning of September, obtained from mooring observations. **b,** Same as in **a** but for F_{LS} and SSS in the Labrador Sea, based on the hydrographic records shown in Supplementary Fig. 1. **c,** Extended time series. All parameters have been normalized by their means and standard deviations over the displayed period.



Supplementary Figure 4 | Summer constraints on the hydrographic evolution in the Irminger Sea. a,b,c, Correlation of salinity, temperature and stratification in the Irminger Sea with F_{IS}. **d,e,f,** Same with F_{LS}. The underlying time series have been obtained from the hydrographic time series shown in Supplementary Fig. 1. Thick contours delineate the 95% confidence level and thin contours represent isolines at intervals of 0.2.



Supplementary Figure 5 | Partitioning of stratification in the Labrador Sea. a,b, Regression of the heat losses H_T and H_S needed to erode the temperature and salinity gradients in the upper 200 m onto F_{IS} and F_{LS}, based on the linearized equation of state. Positive values imply a surplus in the stored potential energy. **c,d,** Same as in **a** and **b** but for the heat loss H_ρ required to overcome the density gradient. Envelopes indicate the 95% significance intervals.

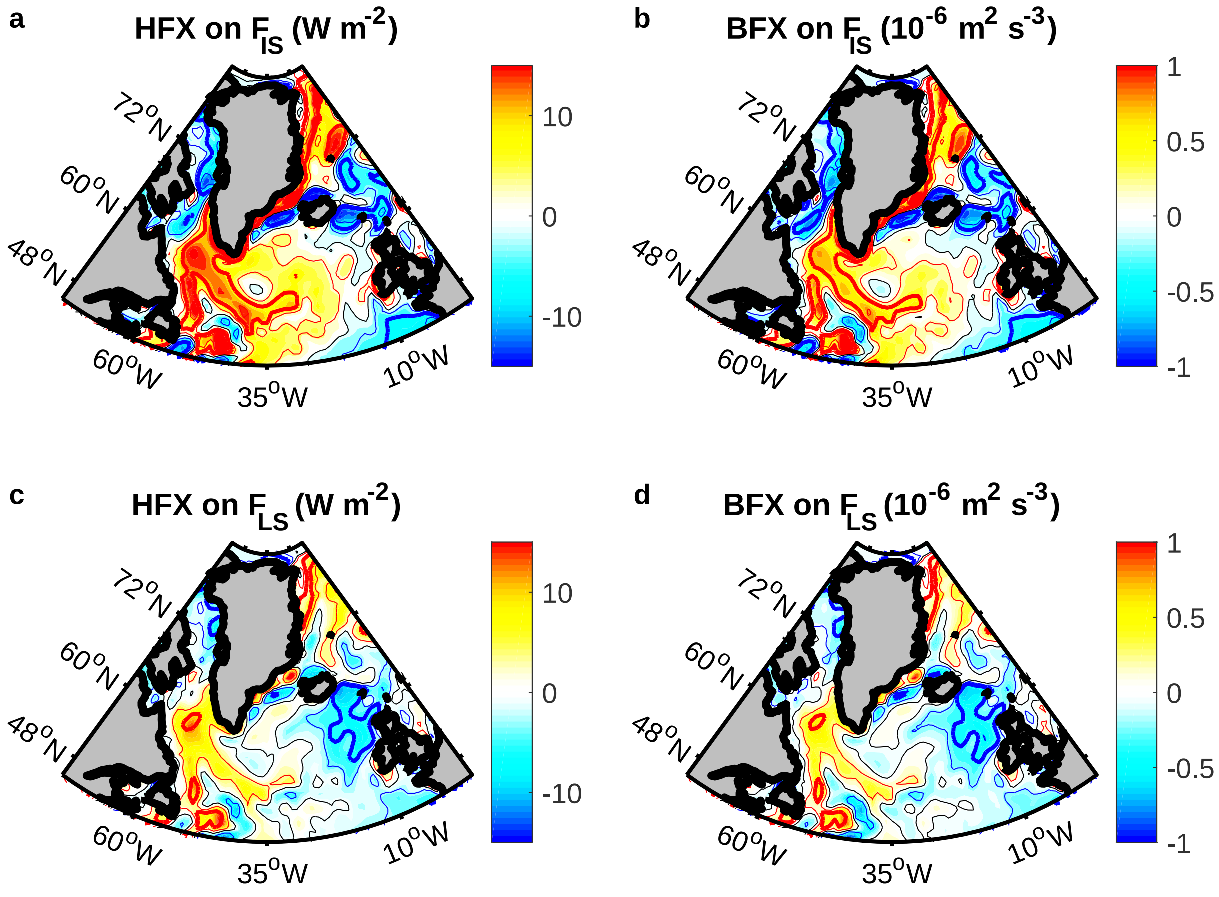
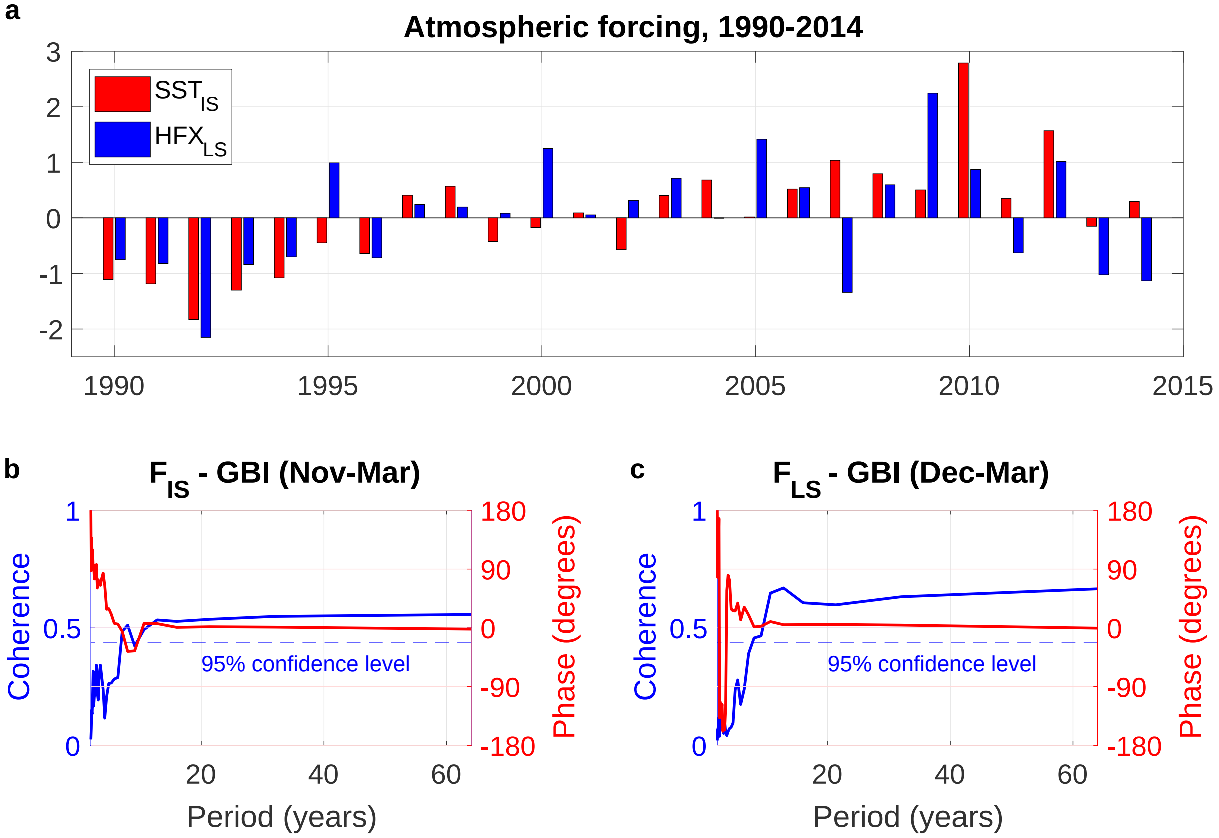
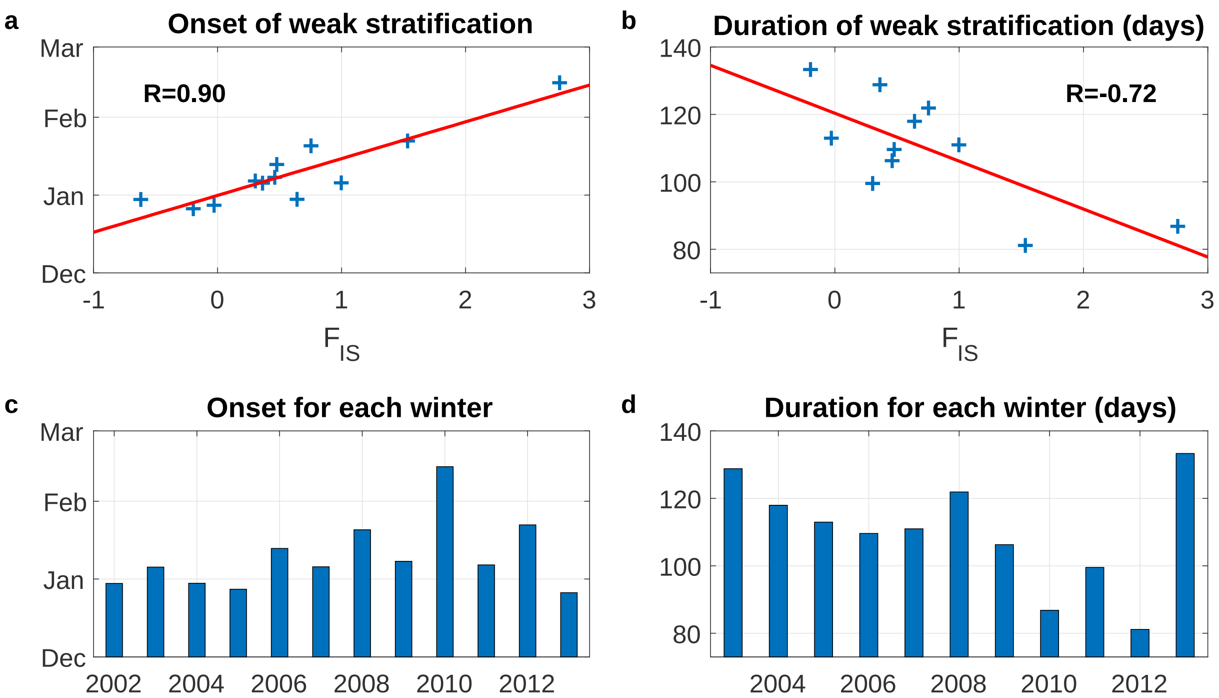


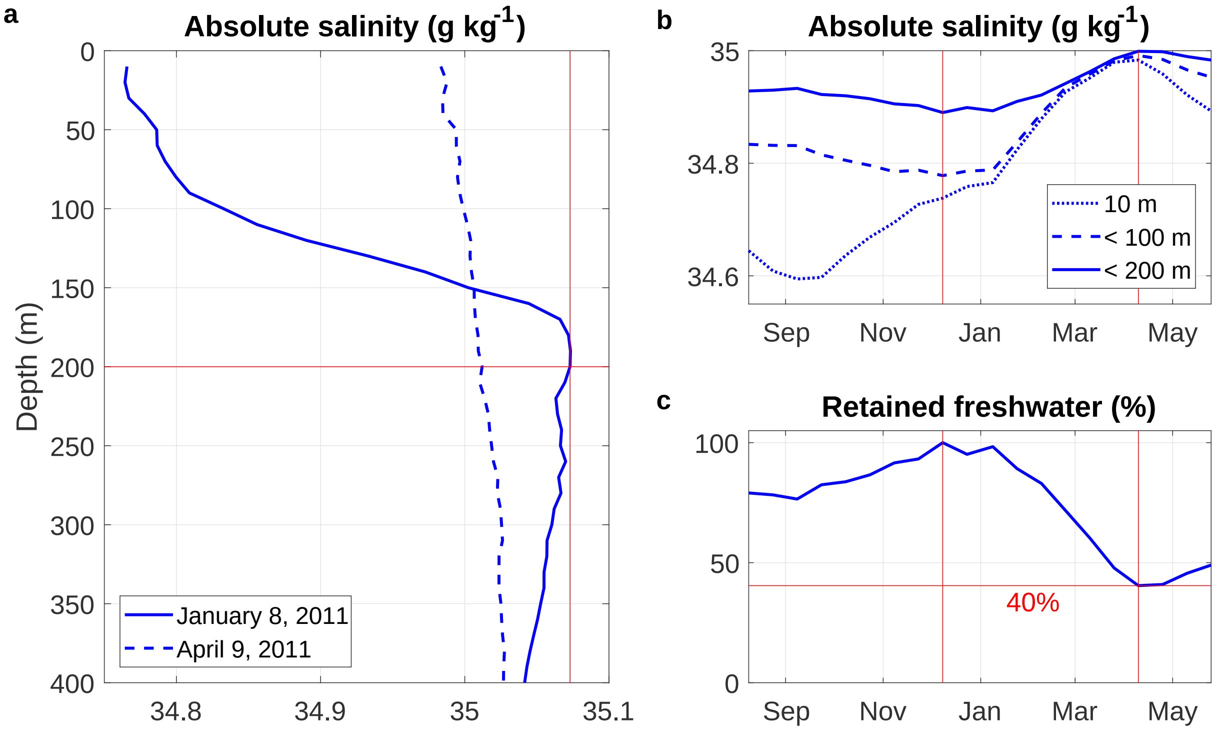
Figure 6 | Summer constraints on the surface fluxes. a,b, Regression of the downward heat and buoyancy fluxes (HFX and BFX) from September through March onto F_{IS}, calculated from reanalysis data. **c,d,** Same as in **a** and **b** but for F_{LS}. Thick contours delineate the 95% confidence level and thin contours show isolines of the correlation at intervals of 0.2.



Supplementary Figure 7 | Long-term seasonal dependencies. a, Normalized SST in the Irminger Sea in August (F_{IS}) and normalized downward surface heat fluxes in the Labrador Sea from November through March, assigned to the year in which they start. **b,c,** Phase difference and coherence between F_{IS} or F_{LS} and the GBI for the period 1950–2014. F_{IS} is based on the Hadley Centre SST record and the GBI represents the 500 mb geopotential height from the NCEP/NCAR reanalysis, averaged between 60 N and 80 N and between 80 W and 20 W.



Supplementary Figure 8 | Summer constraints on convection in the Labrador Sea. a,b, Onset and duration of weak stratification (conducive to convection), defined as the time when the vertical density gradient in the upper 300 m is less than 5×10^{-4} kg m^{-4}, using linear interpolation between neighboring time steps. **c,d,** Same as in **a** and **b** but for each winter, where winters are assigned to the year in which they start.



Supplementary Figure 9 | Retention of freshwater through the winter 2010–2011. **a,** Absolute salinity profiles from the Labrador Sea in January and April 2011. The reference level and salinity arising from the subsurface salinity maximum are indicated by red lines. **b,** Mean absolute salinity over the upper 10, 100 and 200 m from summer till spring. **c,** Percentage of freshwater in the upper 200 m relative to the peak. The red lines in **b** and **c** mark the times of the maximum and minimum freshwater anomalies in the upper 200 m.

Winter	S_{ref}	FW_{max} (m)	FW_{min} (m)	$FW_{retained}$ (%)
2002–2003	35.02	0.87	0.02	2
2003–2004	35.04	1.08	0.12	11
2004–2005	35.04	0.62	0.21	35
2005–2006	35.05	0.63	0.16	25
2006–2007	35.05	0.99	0.27	27
2007–2008	35.04	1.07	0.18	17
2008–2009	35.06	1.59	0.39	25
2009–2010	35.04	0.90	0.25	28
2010–2011	35.07	1.04	0.42	40
2011–2012	35.05	1.07	0.33	31
2012–2013	35.04	1.29	0.30	23
2013–2014	35.01	1.02	0.04	4
Corr. with F_{IS}	0.77	(0.32)	0.76	0.67
Corr. with F_{LS}	0.67	0.58	0.84	0.58

Supplementary Table 1 | Annual retention of freshwater. Reference salinity (S_{ref}), defined as maximum salinity at 200 m depth after each summer, maxima and minima of the freshwater anomalies between summer and the following spring (FW_{max} and FW_{min}), and the percentage of retained freshwater relative to the assumed peak. FW_{max} and FW_{min} are specified as the height of the freshwater column to be added to 200 m deep water with a salinity of S_{ref} to arrive at the observed salinity ($\int_{-200\,m}^{0\,m} \frac{S_{ref}-S}{S_{ref}} dz$). The last two lines display the correlation coefficients with F_{IS} and F_{LS}, unbracketed values being significant at the 95% confidence level.

References

1. Mote, T. L. Greenland surface melt trends 1973–2007: Evidence of a large increase in 2007. *Geophysical Research Letters* **34** (2007).